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THE INFLUENCE OF DAILY FEEDING FREQUENCY ON GROWTH AND FEED CONSUMPTION OF RAINBOW TROUT FINGERLINGS (*ONCORHYNCHUS MYKISS*) REARED AT 18.5-22.5°C

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Abstract

Feed consumption, growth and feed conversion ratios were studied in rainbow trout (*Oncorhynchus mykiss*) juveniles (mean weight 9.0 ± 3.1 g) fed two, three or four times daily and reared at 18.5-22.5°C. The fish reached final mean weights of 26.8-31.6 g over the 40-day trial and growth rates (SGR) ranged 2.57-3.01% per day. Fish fed four times a day had a significantly higher SGR and final mean weight than those fed two or three times each day. Similarly, the condition factors of the groups fed three or four times a day were higher than that fed twice ($p < 0.01$). Daily feed consumption rates (3.1-3.7% of the body weight) increased significantly with increasing feeding frequency ($p < 0.05$), while differences in feed conversion ratios (1.06-1.16) were significant only between the groups fed two and three times ($p < 0.01$). At water temperatures of 18.5-22.5°C, rainbow trout juveniles fed four times a day grow faster than those fed two or three times.

Introduction

Growth and feed conversion are important factors in determining the success of fish culture. Both may be influenced by fish behavior, feed quality, daily ration, water temperature and feeding routine. Given that feed costs account for 40-60% of the operating costs in intensive culture systems, the size of the daily ration and the frequency and timing of feedings are key factors of feed management that influence

growth, feed conversion and the economics of a farming operation (Kaushik and Gomes, 1988; Cho, 1992; De Silva and Anderson, 1995; Goddard, 1996).

Optimal feeding frequency varies with species, age, size, environmental factors, husbandry and feed quality (Storebakken and Austreng, 1987; Goddard, 1996). Piper et al. (1982) suggested that 15.1-45.0 g rainbow

trout should be fed three times daily with each meal being about 1% of the body weight. This can be used as a guide to daily feed requirements and feeding frequency, but it is uncertain whether this guideline applies to fish held at temperature extremes for the species.

The aim of the present study was to determine the optimum feeding frequency for rainbow trout (*Oncorhynchus mykiss*) juveniles (9-32 g) reared at relatively high water temperatures (up to 22.5°C).

Materials and Methods

The trial was conducted from July 22 to September 2, 1999, at the Aquaculture Research and Production Unit, Karadeniz Technical University, in northeastern Turkey. Six fiberglass tanks (diameter 90 cm), with an operating volume of 220 l, were used. Fresh water was supplied at 1-5 l/min depending on the fish size and water temperature.

Three hundred 6-month-old rainbow trout weighing 4.4-14.7 g (mean 9.0 ± 3.1 g) were distributed among the six tanks with 50 fish in each. The fish were acclimated to trial conditions for seven days and weighed to the nearest 0.01 g to determine mean initial weights of the groups. The groups were allocated to one of three daily feeding frequencies: F2 - twice a day, F3 - three times a day and F4 - four times a day. The initial mean group weights were 9.09 ± 3.2 , 8.90 ± 2.6 and 8.95 ± 2.5 g for F2, F3 and F4, respectively. The initial stocking density was 0.45 kg/tank or 2.04 kg/m³.

Fish were fed to apparent satiation with commercial 2.0 mm pelleted trout feed (Abalioglu Yem, Denizli, Turkey) containing 45% crude protein, 11-14% crude lipid and 8.5% water. Feed was provided by hand either two (at 9:00 and 16:00), three (at 9:00, 12:45 and 16:00) or four (at 9:00, 11:30, 13:30 and 16:00) times a day. Feed consumption (feed given to fish), mortality, water temperature and dissolved oxygen were recorded daily. Dead fish were weighed and replaced immediately by fish of a similar size to maintain the number of stock in the tank. Growth was followed by bulk-weighing the fish in each tank to the nearest 5 g approximately every 10 days. Fish were weighed individually at the end of the trial. Total

lengths (± 1 mm) were measured using the von Boyer trough (Piper et al., 1982) and used to calculate condition factors. When fish were handled individually (during weighing or/and measuring) they were anesthetized using 50 ppm MS-222.

Data were used to calculate growth performance (increase in weight), specific growth rate ($SGR = [(\ln W_t - \ln W_o)/t] \times 100$), biomass (kg/m³), feed consumption (FC) as a percent of the biomass ($[\text{feed consumed per day}/\text{mean body weight}] \times 100$), feed conversion ratio ($FCR = FC/[W_t - W_o]$) condition factor ($[\text{weight}/\text{length}^3] \times 100$) and coefficient of variation ($CV = [SD/\text{mean}] \times 100$), where W_o and W_t were weights (g) at the beginning of and during the experiment and SD was the standard deviation. Mean tank data ($n=2$) were used and subjected to one-way analysis of variance (ANOVA). Differences between means were compared by the Tukey test at a 95% interval of confidence ($p < 0.05$).

Results

Mean water temperature and dissolved oxygen content ranged from 19.3 to 21.6°C and from 7.8 to 8.4 mg/l, respectively, but daily variations in temperature were higher (15.0-22.5°C).

At the end of the trial, mean live weights of the fish reached 26.79 ± 6.92 ($n=100$), 28.21 ± 8.21 ($n=100$) and 31.62 ± 8.01 g ($n=100$) in groups F2, F3 and F4, respectively (Table 1). The final weight and SGR of F4 were significantly higher than those of the other groups ($p < 0.05$). The condition factor increased amongst the fish fed three or four times per day but decreased in those fed only twice. The difference in condition factor between F2 and the other two groups was significant ($p < 0.01$).

Daily feed consumption fluctuated during the trial from 2.31 to 4.20% of the live weight. Mean values increased with increasing feeding frequency and differences between the groups were significant ($p < 0.05$). The best (i.e., lowest) mean FCR was obtained in the twice daily feeding (F2) followed by the four times a day and three times a day feedings, but the difference was significant only between F2 and F3. Except in the F2 treatment, the FCR decreased as the trial period progressed.

Table 1. Body weight, specific growth rate (SGR), condition factor, feed conversion ratio (FCR), biomass and net yield of rainbow trout fingerlings during the 40-day feeding frequency trial.

	Two feedings per day (F2)		Three feedings per day (F3)		Four feedings per day (F4)	
	Mean	Coefficient of variation	Mean	Coefficient of variation	Mean	Coefficient of variation
Initial weight (g)	9.09±3.2	1.93	8.90±2.6	2.13	8.95±2.5	0.45
Final weight (g)	26.79±6.92 ^a	4.66	28.21±8.21 ^b	1.06	31.62±8.01 ^c	0.32
SGR (%/day)	2.57 ^a	2.33	2.77 ^b	1.44	3.01 ^c	0.50
Initial condition factor	1.39	6.88	1.34	8.02	1.35	6.99
Final condition factor	1.35 ^a	5.25	1.47 ^b	6.79	1.49 ^b	5.58
FCR	1.06 ^a	0.94	1.16 ^b	0.86	1.10 ^{ab}	1.81
Initial biomass (kg/tank)	0.45	-	0.45	-	0.45	-
Final biomass (kg/tank)	1.34 ^a	-	1.41 ^b	-	1.58 ^c	-
Net yield (kg/tank)	0.89	-	0.97	-	1.13	-

Different superscript letters indicate significant differences.

NS = Not significant, * p<0.05, ** p<0.01

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Discussion

When juvenile rainbow trout (8.9-31.6 g) were fed to satiation at different feeding frequencies in relatively high (up to 22.5°C) water temperatures, the greatest weight gain ($p < 0.05$) was observed amongst the fish fed most frequently (four times a day). Results showed that for maximum growth, the daily feeding rate should be around 3.7% of the body weight of the fish, while it should be around 3.1% for the best feed conversion. The feeding rate which produced the best growth (that of F4) agrees with values recommended by Goddard (1996) for this size range at a water temperature of 20°C. In general, the feeding rate increases with water temperature from 2-4°C up to 18°C, maximum 20°C. In contrast, it decreases as the fish grow. During the present study, consumption rates decreased with the slightly increasing temperature and rose again as the temperature dropped to initial levels, but there was no variation with increasing fish size, as was expected.

In general, feed conversion improves with increasing feeding frequency (Goddard, 1996). It decreases with increasing feed supply until a certain rate, then increases rapidly. The amount of feed presented to the fish in this study varied with the feeding frequency. The feed supplied at each feeding for group F2 was higher (1.54% of the body weight) than for F4 (0.91%) and F3 (1.14%). However, the lowest feed conversion rate was obtained in the F2 group, indicating that feed taken by fish fed twice a day was insufficient for maximum growth but optimum for feed conversion. Salmonids are known as good feeders and, according to De Silva and Anderson (1995), when these fish are fed to satiation, they tend not to eat again until the stomach is almost completely evacuated. Therefore, a feeding frequency of once or twice a day might be sufficient. However, this rule does not appear to be valid for the size fish used in the present trial or for high water temperatures in which the stomach evacuation time is considerably shorter.

Feeding rates, growth and feed conversion are major variables for commercial aquaculture enterprises. An understanding of the relationships between these is necessary to optimize fish feeding. Daily feeding frequency is a useful tool, particularly when seeking to balance maxi-

mum growth with optimal food conversion. A high feeding rate together with frequent feedings results in the best performance (Stickney, 1994). This seems to be the case in our study since growth was highest in fish given a daily feeding rate of 3.64% in four feedings (F4), while the FCR did not differ from that in fish fed at the lowest rate (F2).

In summary, daily feed consumption of rainbow trout fingerlings, even at water temperatures approaching upper tolerance limits, may be as high as 4.0% of the live weight and feed should be presented at least four times a day or as recommended by Piper et al. (1982) at a rate of 1% each time. While the study supports previous studies and provides clear evidence of the effect of daily feeding rate and frequency on growth and feed conversion of rainbow trout fingerlings, the relationship between feed costs, these variables and water temperature need further study.

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